Processing and Representation of Different Types of Czech Affixes

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ABSTRACT:
The study investigates the processing of morphologically complex words in Czech. In Experiment 1 we employed morphological repetition priming to test the Split Morphology Hypothesis, i.e. whether derived and inflected word forms are stored in the same or different manner in the Czech mental lexicon. The results demonstrate significantly larger priming effects for inflected forms compared to derived forms indicating distinct processing of inflection and derivation in Czech; while inflected forms are fully decomposed during language comprehension, derived forms are either not, or only partially. In Experiment 2 we addressed two research questions. First, we tested the psycholinguistic reality of the linguistic distinction between two types of inflective verbal prefixes: (a) "purely" inflective aspectual prefixes (i.e. the prefix turns an imperfective verb into a perfective one as in *hřešit* (imp.; 'to sin') — *zhřešit* (perf.)) and (b) derivational verbal prefixes (e.g. *krátit* (imp.; 'to shorten') — *zkrátit* (perf.)). The results did not indicate any evidence that this distinction would be psycholinguistically grounded. Second, we examined the role of semantic transparency of the derivational prefixes in the processing. The experiment delivered evidence of slower processing of opaque derived verbs, most likely caused by double search/reanalysis.

KEY WORDS:
affixes, aspect, Czech, derivation, inflection, lexical decision, priming, semantic transparency

INTRODUCTION

The processing of morphologically complex words and the nature of their mental representation have been hotly discussed topics in psycholinguistic debates during the last decades. Is a morphologically complex word decomposed before being accessed? Are affixes represented independently of the stem? Does the processing of different types of affixes proceed in a different manner?

These and similar questions have been addressed in several languages, however without conclusive results. Some studies suggest that complex words are accessed in their full forms, especially if they are concerned with semantically opaque (Sandra, 1990; Monsel, 1985; Marslen-Wilson et al., 1994), morphologically irregular (Ullman, 2001; 2004; Ullman et al., 2002; Pinker, 1997; 1998; 1999; Pinker — Ullman, 2002; Clahsen — Aveledo — Roca, 2002; Münte et al., 1999; Newman et al., 2007; Allen — Badecker — Osterhout, 2003), or very frequent and common inflected forms (Monsel, 1985; Sandra, 1990). On the contrary, other findings support morphological decomposition, i.e. accessing words through their components, particularly in the case of transparent compounds (Jarema et al., 1999; Zwitserlood, 1994; Sandra, 1990) and/or transparent complex words (Marslen-Wilson et al., 1994) or regular inflected

forms (Ullman et al., 2002; Ullman, 2004; Pinker, 1999; Münte et al., 1999; Newman et al., 2007; Allen — Badecker — Osterhout, 2003). In general, there is no agreement about how morphologically complex words are accessed, both across languages and with respect to various phenomena within one language (for review of conflicting results see McQueen — Cutler, 1998).

What previous research did show with certainty is that results from one language cannot be readily-generalized to other languages. For example, the so-called Split Morphology Hypothesis (Anderson, 1988) claiming that inflection and derivation are two different mental processes, was found valid in English (Stanners et al., 1979), Dutch (Bertram et al., 2000), Finnish (Bertram — Laine — Karvinen, 1999) and German (Schriefers — Friederici — Graetz, 1992), however, could not be confirmed for Hebrew (Feldman — Bentin, 1994).

A linguistic phenomenon that is cross-linguistically identified as "the same" can thus be underlied by different morphological processes and mental structures, making the testing of a broad scope of individual languages a sine qua non for verifying general claims. Independently from this fact, different languages open different possibilities for testing both new and old hypotheses about language processing and representation (e.g. Bordag — Pechmann, 2009). The psycholinguistic examination of the Czech language as presented in this study can thus provide unique insights both into morphological processing in general and into a specific language with a rich inflectional system with various types of affixes in particular. In our study we focus on the processing of selected types of affixes and their representation in the Czech mental lexicon.

PROCESSING OF MORPHOLOGICALLY COMPLEX WORDS

As indicated in the introduction, there are several hypotheses concerning processing morphologically complex words. According to the so-called Affix Stripping Hypothesis introduced by Taft and Forster (1976), all affixes are stripped at first and then the stem decoding takes place (Rastle — Davis — New, 2004). This Obligatory Decomposition Hypothesis (also e.g. Smith — Sterling, 1982; Taft, 2004) is supported by the results of Taft's (1979; 1981) experiments revealing that the processing of words with the initial part resembling prefixes (e.g. *revise*) takes longer than processing of non-prefixed words (e.g. *divide*). According to Taft, the finding indicates that affix stripping takes place even in such cases: The presumed affix *re-* is first stripped, but since there is no entry for *vise*, the word form has to be reanalysed, which delays the processing. The Affix Stripping Hypothesis assumes links of various strength and character among morphemes constituting morphologically complex words and predicts processing differences with respect to the type of affix (Kiparsky, 1982). A modification of this hypothesis by Colé, Segui and Taft (1997) proposed that the search for complex and decomposed forms proceeds in parallel and that the frequency of the complex form, on the one hand, and of its stem, on the other, crucially determines which search will be faster. The finding that access to complex word forms with high frequent stems is faster than to complex words forms with low frequent stems also supports the

Decomposition Hypothesis (Taft, 1979; 2004; in compounds: Fiorentino — Poeppel, 2007). Further evidence for the decomposition of morphologically complex words comes from studies using masked priming (Rastle — Davis — New, 2004; Lehtonen et al., 2011) or combining masked priming and magnetoencephalography (MEG) (e.g. Solomyak — Marantz, 2010).

The so-called Full Listing Hypothesis (Butterworth, 1983) represents the opposite view assuming that complex words are represented in their full forms without any reference to their constituents. This view was seen as uneconomical with respect to the used capacity in the mental lexicon by listing all inflectional words in the declarative memory. However, decomposition and construction of complex forms puts functional load on working memory in turn. Moreover, recent approaches suggest that significantly more is stored in the memory than originally assumed, including not only frequent full forms, but also frequent chunks of words (Langacker, 1987; Goldberg, 2003; Hanna — Pulvermüller, 2014).

Dual Pathway Models (e.g. Marslen-Wilson et al., 1994; Wurm, 1997) is a term often used for approaches combining both views, i.e. morphological decomposition for some words (typically regular and transparent) and non-decomposition for others. Whether complex words are decomposed or retrieved from memory as complex units is thus related to the nature of their constituents.

Also, supporters of morphological decomposition typically agree that some words, such as irregular verbs (Pinker, 1999; Ullman et al., 2002; Ullman, 2004; Münte et al., 1999; Newman et al., 2007; Allen — Badecker — Osterhout, 2003; Clahsen — Sonnenstuhl — Blevins, 2003; Sonnenstuhl — Eisenbeiss — Clahsen, 1999), forms involving alternations (Caramazza et al., 1985) or even some frequent, common inflected forms and opaque compounds might be stored in the form of a whole non-decomposed word (Monsel, 1985; Sandra, 1990; Bertram — Schreuder — Baayen, 2000; Baayen et al., 2003).

The experiments of Ito, Sugioka and Hagiwara (1996) and Hagiwara et al. (1999) with Japanese complex words indicate that the decomposition process takes place only in regularly affixed words because only then can a rule be applied (cf. also Beretta et al., 2003; an fMRI study with German). Their claims are based on the comparison of data obtained from Broca and Wernicke's aphasics; while Broca's aphasics showed difficulties in the production of regular derivational suffixes, but not in production of irregular ones, the pattern was reversed for Wernicke's aphasics. Vannest and Boland (1999) suggested (based on results for English) a division of affixes into two groups: one comprising productive, phonologically neutral, semantically transparent affixes yielding the decomposition process (e.g. *-less*; *worthless*) and the other with idiosyncratic, structure changing, semantically-opaque affixes that are not decomposed (e.g. *-ity*; *severity*).

Related to the above considerations is the Split Morphology Hypothesis (Anderson, 1977; 1982; 1988; 1992; Matthews, 1972; 1991; Perlmutter, 1988; Scalise, 1984; 1988), according to which derivation and inflection are two different mental processes because two different types of constituents/affixes are involved in these operations. Derivation is considered a word formative process in which a newly-formed word is conceived as a different lexical item with a different meaning (at least to a certain

extent). The derived word also typically belongs to a different word class. On the other hand, inflected forms are considered forms of the same lexeme, i.e. they are variations of the same word and thus have the same lexical meaning. Inflection is predictable because it is (with some exceptions) regular and rule-governed, which cannot be clearly claimed in the case of derivation. Inflectional forms are also more constrained by syntax than derivational forms (Anderson, 1982).

PRESENT STUDY

In the present study two experiments are introduced. The aim of Experiment 1 was to test the potential processing differences between inflected and derivational forms in relation to the Split Morphology Hypothesis in Czech. In Experiment 2, we explored the processing of prefixed verbs with presumably different statuses of their prefixes with respect to inflection and derivation. We intended to test whether the particular linguistic analysis of verbal prefixes corresponds to their mental representation or whether it is rather a linguistic construct not corresponding to any processing correlate. In addition, we also investigated the role of semantic transparency/opacity in the processing of various derivational prefixes.

SPLIT MORPHOLOGY HYPOTHESIS (SMH) IN RELATION TO INFLECTION AND DERIVATION

Our first research question (Experiment 1) was to test SMH in Czech with the main purpose of finding out whether there is a difference between the processing of inflection and derivation in this morphologically very rich language. SMH has been tested, for instance, in English, Italian and German with results indicating different processing of inflection and derivation (Stanners et al., 1979; Fowler — Napps — Feldman, 1985; Laudanna — Badecker — Caramazza, 1992; Schriefers — Friederici — Graetz, 1992). However, as mentioned earlier, the results from Hebrew (Feldman — Bentin, 1994) did not provide any evidence of derivation and inflection as two mentally different processes, which might be ascribed to the non-concatenative nature of Hebrew morphology.

As the nature of a language's morphology obviously plays a role, the hypothesis should not be generalized over different languages before being tested. Slavonic languages, in general and Czech in particular, possess a rich inflectional system with frequent stem changes due to alternations. To our knowledge, the only experiment testing SMH in Slavonic languages was conducted in Serbian by Feldman (1994). Her results provide evidence that the processing of inflection and derivation differs in Serbian, and thus confirm the validity of SMH in this Slavonic language. However, as previous research shows (e.g. Bordag — Pechmann, 2009), evidence from one language of a particular language family does not ensure validity for all languages in the given family and replications are needed to assess the generalizability and the scope of the hypothesis.

Our experiment is thus a partial replication of Feldman (1994) with several adjustments in design. Like Feldman, we examine the processing of inflected and derived nouns and verbs and focus on the facilitation in processing of morphologically related forms.

EXPERIMENT 1

The experiment is an adjusted replication of Feldman (1994). Using morphological repetition priming (identical, inflectional, derivational) with lexical decision, we tap into processing of the derivational and inflectional forms to find out whether different types of suffixes are processed differently and whether SMH (claiming that derivation and inflection are different mental processes) is valid also for the Czech language.

PARTICIPANTS

Twenty-three Czech native speakers, all right-handed university students (9 men, 14 women, aged 20–30 years), participated in the experiment. They were remunerated for participating in the study.

STIMULI

A battery suitable for Czech speakers was constructed from nouns and verbs in three forms (basic form, inflectionally related form, derivationally related form).[1]

Twenty-seven Czech word triples were selected. Fifteen triples consisted of a noun target in the nominative (basic form that served also as an identity prime), an inflectionally related form in instrumental and a derivationally related verb form. That is for instance: the nominative target *HMAT* ('a touch') constitutes a pair with prime in the instrumental *hmatem* and with the derivationally-related verb *hmatáš* ('you touch') in the 2nd person singular indicative present. Twelve triples consisted of a verb target in the 1st person singular indicative present (basic form) and an inflectionally related form in the 2nd person singular indicative present and a derivationally-related agentive the noun form. For example, target *PLAVU* ('I swim') made a triple with *plaveš* ('you swim') and *plavec* ('a swimmer').

Twenty-seven triples of orthographically and phonemically regular pseudo-words were created by changing one or two letters in real words (vowel for vowel, consonant for consonant). Triplets were organized according to the same principle as real words, i.e. pseudo-words were declined and conjugated as if they were real words, i.e. contained suffixes of existing words.

A further 162 pairs of fillers were constructed in order to prevent expectancy and strategic effects. The primes and targets were always semantically and

1 Only masculine nouns and verb forms of all verbal classes were included in the testing battery.

morphologically unrelated. They were divided into three subgroups of 54 items. In the first group the prime and the target were of the same type (i.e. word — word or pseudo-word — pseudo-word). For example, word — word pairs were such as *DĚLÁM* ('I do') — *PATŘÍM* ('I belong to') or *HROZEN* ('a grape') — *SEVER* ('north').

The pair members of the items in the second group were of a different type with the primes being words and the targets pseudo-words, or vice versa. Thus *TEPLO* ('warm') — *KODLOM* and *HUNKUJU* — *BRUSLÍM* ('I'm skating') were matched.

Items in the last group were paired in the same manner as in the second group, but there was a phonological overlap between their first syllables that were identical e.g. *FARMÁŘ* ('farmer') — *FARPON*, or *TÉMA* ('theme') — *TÉNO*.

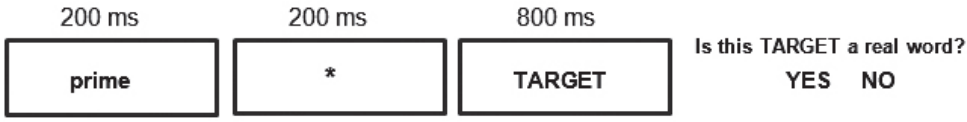
All items included in the battery were 3–7 letters long. Primes were 1–2 letters longer than targets and both were perfectly matched phonemically and orthographically. To ensure perfect overlap, neither alternations nor softening or shortening were included. Ambiguity of any sort was avoided as well. All words were assumed highly familiar for Czech native speakers.

PROCEDURE

The morphological priming experiment was designed in E-Prime software (E-Prime, v. 1.2; Schneider — Eschman — Zuccolotto, 2002).

Each test consisted of 684 prime-target pairs, of which 162 items were of interest. At first, a prime appeared on the screen for 200 ms, followed by a fixation sign for 200 ms and finally by a target for 800 ms. Primes appeared in the middle of the screen in lower-case letters and targets in capital letters (to avoid graphical overlap and highlight the items to which participants should respond), both printed in Courier New script 18. Participants performed lexical decision on the target by determining whether it is an existing Czech word by pressing the YES or NO button on a keyboard. Reaction times on targets were measured. Primes were either identical with targets or they were their inflections or derivations. This approach, rather than presenting the inflected/derived forms as targets, was taken to avoid confusion about the lexical status of the inflected forms (especially for nouns) presented without context.

The experimental paradigm can be illustrated as following:



The battery was divided into three blocks which were randomized into three different orders. The initial six items in each block served as fillers and were not included in the analysis. Items in each block were randomized automatically. One testing lasted approximately 25 minutes. Before the test phase participants performed a brief practice phase consisting of 12 items.

RESULTS AND DISCUSSION

Reaction times slower than 680 ms (17.9%) were excluded from the analysis as outliers on the basis of Feldman's (1994) experiment.

Reaction times for identity, inflectional and derivational priming with words are presented in Table 1. One factorial analyses of variance (ANOVAs) with the factor Type of Prime (three levels: identity, inflectional, derivational) was performed over the target latencies for the critical items using subjects (F1) and items (F2) as random variables. The effect of Type of Prime revealed a difference in the reaction times between the three groups: $F1(46,2) = 4.66$, $p < .05$; $F2(52,2) = 5.78$, $p < .01$.

A Scheffé test revealed that the reaction times in the identity and inflectional condition were statistically the same, but that they both significantly differed from the derivational condition ($p < .05$) where the reaction times on the target were slower. This suggests different processing of inflectional and derivational forms. In other words, the priming effect due to derivationally-related primes was significantly weaker than the priming effect due to inflectionally related primes.

	Primes								
Example	**Identity prime**			**Inflectional prime**			**Derivational prime**		
	PLAVU (1.Sg.Pres.Ind.)			PLAVU (1.Sg.Pres.Ind.)			PLAVU (1.Sg.Pres.Ind.)		
	PLAVU (1.Sg.Pres.Ind.)			PLAVEŠ (2.Sg.Pres.Ind.)			PLAVEC (agentive noun)		
	or								
	HMAT (nominativ)			HMAT (nominativ)			HMAT (nominativ)		
	HMAT (nominativ)			HMATEM (instrumental)			HMATÁŠ (related verb)		
Word	RT (ms)	Nr.	ERR (%)	RT (ms)	Nr.	ERR (%)	RT (ms)	Nr.	ERR (%)
	524.86	530	3	524.36	514	4	536.45	521	4

TABLE 1: RTs and error rates with real-word targets.

The statistically identical identity and inflectional priming might be interpreted as a result of accessing the same lexical entry for all inflected word forms. Smaller priming effect observed in derivationally primed items suggests access involving a more complex structure that e.g. employs more nodes or different types of links among constituents as derived word forms might be only partially decomposed or might not be decomposed at all. In the latter case, two different entries would be accessed in the mental lexicon.

Analyses including word class (nouns vs. verbs) as a factor revealed that nouns were processed significantly faster than verbs ($F1(1,22) = 11.9$, $p < .01$; $F2(1,24) = 8.6$, $p < .01$ and that there was no difference in the priming between the two word classes ($Fs < 1$) (see Table 2). Faster processing of nouns in words might result from the fact that target nouns were in basic forms in the nominative singular, while target verbs were in the 1st person singular present. Thus, while noun target had a zero final morpheme, verb targets involved an inflectional suffix. This fact might be considered only in the processing of identity and inflectional forms.

	Word		Pseudoword	
Target	**Noun**	**Verb**	**Noun**	**Verb**
Identity priming	514.94	537.22	567.05	582.77
Inflectional priming	517.40	532.95	566.48	588.61
Derivational priming	531.15	543.42	569.60	585.26

TABLE 2: Mean RTs for nouns and verbs in real words and pseudo-words conditions.

Separate analyses were performed over the control filler pseudo-words revealing no significant differences between the three conditions (see Table 3). This finding shows that the observed differences between inflection and derivation are of a morphological nature and not an artefact of the employed suffixes: When attached to pseudo-words, no difference in priming effect was observed showing that the orthographic overlaps alone cannot account for the results with existing words.

	Primes								
	Identity prime			**Inflectional prime**			**Derivational prime**		
Example	PIRU (1.Sg.Pres.Ind.)			PIRU (1.Sg.Pres.Ind.)			PIRU (1.Sg.Pres.Ind.)		
	PIRU (1.Sg.Pres.Ind.)			PIREŠ (2.Sg.Pres.Ind.)			PIRAN (agentive noun)		
	or								
	KEZ (nominativ)			KEZ (nominativ)			KEZ (nominativ)		
	KEZ (nominativ)			KEZEM (instrumental)			KEZÍŠ (related verb)		
Pseudo-word	RT (ms)	Nr.	ERR (%)	RT (ms)	Nr.	ERR (%)	RT (ms)	Nr.	ERR (%)
	573.53	342	11	574.96	329	13	575.40	359	10

TABLE 3: Mean RTs and error rates with pseudo-word targets.

The experiment confirmed the results of previous studies in English, German, Dutch, Italian and Serbian: priming was significantly smaller when the prime was a derived, rather than an inflected, form. The finding indicates that derivation and inflection are two distinct mental processes in Czech as well.

THE MORPHOLOGICAL STATUS OF CZECH VERBAL PREFIXES

The status of verbal prefixes with respect to derivation and inflection is highly controversial in Czech. Most research agrees that verbal prefixes typically combine two functions: (a) lexical (they are considered to be word-forming means), and (b) grammatical (they mark aspectual changes). The controversy concerns especially a group of verbs whose prefixes are purely grammatically or lexically empty according to some research (e.g. Kopečný, 1962; Šlosar, 1981; 1986). According to these authors, the important property of verb forms with such prefixes is their inability

to be turned into secondary imperfective forms (or the frequency of these forms is very low). As an example, the verb *ničit* ('to keep destroying') can be turned into a perfective verb by adding the prefix *z-*, i.e. *zničit* ('to destroy'), but the secondary imperfective form **zničovat* is ungrammatical. On the other hand, perfective verbs with prefixes that also have a lexical function can be turned into secondary imperfective verbs, e.g. *zkrátit* ('to shorten'), *utlumit* ('to deaden') and these again into secondary imperfectives *zkracovat*, *utlumovat*. Thus, although prefixation is generally considered to be a word formation process (new words are produced, not just new forms of a word), in purely aspectual prefixation prefixes do not form new lexemes, but only change the grammatical function of the given verb. According to this approach, the lexical prefixes are classified as derivation, while the purely aspectual affixes are classified as inflection.

The controversial status of verbal prefixes, in general, and the existence of purely aspectual prefixes, in particular, has been a subject of discussion for many years not only in Czech, but in other languages such as Russian. Endresen et al. (2012) argue that the traditional assumption that prefixes are semantically "empty" when used to form aspectual pairs is problematic because the same prefixes are clearly "non-empty" when combined with other base verbs (in Czech the example of a semantically empty prefix can be found in *skončit* ('to end'), however, the prefix *s-* cannot be declared as empty in *smést* ('to sweep away', 'to sweep together') as it expresses the meaning 'away from the surface' and 'together'). Endresen et al. (2012) also proposed that prefixes are not empty, but instead have meanings that overlap with the meanings of the base verbs. This is valid also for Czech. Uher (1987) claimed (about Czech) that verbal prefixes do not express perfective aspect only even in "purely" aspectual forms and therefore it is the most adequate to consider aspect as a lexically-grammatical category ("Slovesný vid je proto nejvhodnější považovat za lexikálně-gramatickou kategorii […]" (Uher, 1987, p. 46).) Other linguists (e.g. Maslov, 1963; Komárek, 2006; Veselý, 2010) also asssume that "purely" aspectual prefixes do not exist.

A different opinion is held, for instance, by Kopečný (1962) and Šlosar (1981; 1986). According to their views, some purely aspectual prefixes do not express any lexical meaning and some express a semantic feature which already constitutes a part of semantics of the verbal meaning itself. In these cases the prefix appears lexically empty and "purely" aspectual ("Prefix vyjadřuje významový rys, který je součástí sémantiky slovesného významu samého. V takových případech se prefix jeví navenek jako lexikálně prázdný, prostě vidový" (Šlosar, 1986, p. 339).) Veselý (2010), who sees a contradiction in the statement itself, disagreed with this claim. According to him, it is not possible to claim simultaneously that a certain prefix has and, at the same time, does not have a lexical meaning (because the meaning is repetitive or implicitly present in a fundamental verb) ("Není možné současně tvrdit, že určitá předpona lexikální význam má i nemá. Nelze tvrdit, že ho vlastně jakoby nemá proto, že jde o význam opakovaný (nebo implicitně přítomný i ve fundujícím slovese)" (Veselý, 2010, p. 118).)

In Experiment 2, we explored whether the distinction between derivational and purely aspectual affixes proposed by some authors is psycholinguistically grounded.

THE ROLE OF SEMANTIC TRANSPARENCY ON MORPHOLOGICAL PROCESSING

The meaning of some morphologically complex words can be derived from their constituents and in such cases the complex words are considered semantically transparent. A semantically transparent word is, for instance, *impoliteness* consisting of a negative prefix *im-*, *polite*, and the noun-formative suffix *-ness*. On the other hand, the meaning of the word *department* is opaque: it is not obviously related to its components because it has nothing in common with the word *depart*.

Schreuder and Baayen (1994; 1995) claimed that semantic transparency determines whether a morphologically complex word is processed through its constituents. Whereas constituents of semantically transparent words such as *friendly* are assumed to be routinely activated during word recognition, the processing of semantically opaque words such as *department* does not seem to involve the activation of its constituents. Studies by Marslen-Wilson et al. (1994) and Rastle et al. (2000) support this view. They revealed that word base is primed by a semantically transparent and morphologically complex word (*government* primes *govern*), but not with a semantically opaque word (*apartment* does not prime *apart*).

Findings from research on semantically transparent and opaque compounds deliver further evidence for differences in semantic representations with respect to semantic transparency/opacity (Zwitserlood, 1994; Libben, 1998; 2003). The key role of semantics in morphological decomposition is evident also from studies by Giraudo and Grainger (2000), Plaut and Gonnerman (2000) and Rueckl et al. (1997).

Moreover, the results of Longtin et al. (2003) reveal that semantically transparent words such as *darkness — dark* cause greater priming effect than words with pseudo-morphological relation (cf. Rastle — Davis — New, 2004, for different results), e.g. *corner — corn* and both of these types show greater effects than non-morphological pairs, e.g. *brothel — broth* (because *-el* is not a suffix in English). These results suggest that the priming effect is not caused only by orthographic overlaps, but involves morphological processing.

Even though the meaning of the Czech prefix tends to be transparent in many words, prefixes carry many functions and nuances in meaning. Peciar (1966) claimed that, for instance, the prefix *u-*, used also in our experiment, has one of the most abstract meanings and various functions which are for instance separation (*ukrojit* — 'to cut off'; *ulomit* — 'to break off'; *useknout* — 'to chop off'), a small amount (*upít* — 'to take a sip'; *usmát se* — 'to give a smile'; *uchechtnout se* — 'to giggle') and a change in the state (*usmířit se* — 'to become reconciled'; *učesat* — 'to comb'; *upálit* — 'to burn off').

In general, the most frequent prefixal meanings in prefixed verbs are direction, measure, resultativeness and time. According to Uher (1987), it is only the semantics of the base verb which creates the specific meaning of prefix (he distinguishes 242 meaning features of different Czech prefixes). Prefixes thus obtain different meaning nuances in connection with a certain base verb. The lexical semantics of the verb changes through prefixation and Uher defines the meaning of the prefix as the manifested change in the target verb meaning compared to the original meaning

of the unprefixed verb ("[t]o, čím se účast předpony konkrétně projeví při lexikálně sémantické změně slovesa základového v nově utvořené" (Uher, 1987, p. 22)).

Following the claims of Schreuder and Baayen (1994; 1995) and other authors, semantically opaque and transparent words are processed differently. Does it therefore imply that prefixes/words such as *zhřešit* ('to sin') and *zkreslit* ('to distort') are processed in a different way because the latter is a semantically opaque word (*kreslit* means 'to draw') even though they share the same prefix, i.e. they can be morphologically analysed as *z-hřešit* and *z-kreslit*? Do semantic transparency and the type of morpheme also play a role in the recognition of prefixed verbs?

EXPERIMENT 2

The main goals of Experiment 2 were (a) to experimentally test the distinction between derivational vs. inflectional verbal prefixes and (b) to investigate whether the recognition of semantically opaque prefixed verbs differs from the recognition of semantically transparent prefixed verb. Employing lexical decision task, we compared response latencies between the following groups of verbs:

(a) Inflectional prefixes without any lexical meaning — "purely" aspectual prefixes.
(b) Derivational prefixes changing the meaning of the word.
    1. Transparent — the meaning can be derived from the constituents: *kreslit* ('draw') — *vykreslit* ('colour in').
    2. Opaque — the meaning of the word cannot be obtained from the constituents: *kreslit* ('draw') — *zkreslit* ('distort').

PARTICIPANTS

Twenty-three native Czech speakers participated in the experiment, 7 men and 16 women. All together 25 participants took part in the task, but two of them had to be excluded due to high error rates throughout the experiment. Participants were university students between the ages of 20 and 29. All participants were right-handed. They were remunerated for participating in the study.

STIMULI

The battery consisted of 780 items, of which 270 were target words, 170 fillers and 390 pseudo-words.

All items were verbs in the 3rd person singular present indicative either in the perfective or imperfective form. Neither alternations nor secondary imperfective forms nor reflexive verbs requiring reflexive complement "se/si" were included in the battery.

The average length of each item was 5–6 letters (items were matched within the group and also across all groups). There was one letter difference between the perfective and imperfective forms, with perfective forms being longer. The frequency and cumulative frequency of items was coded based on Český národní korpus (ČNK; corpus SYN).

Since prefixed forms are typically less frequent than their bases it was not possible to match frequency between the groups; it was however considered in the analysis.

The target words in the battery were divided into four categories:

(a) verbs with "purely aspectual prefix": *MIZET* (imp.) — *ZMIZET* (perf.) 'to disappear';
(b) semantically transparent verbs with derivational prefix: *KRÁTIT* (imp.) — *ZKRÁTIT* (perf.) 'to shorten';
(c) semantically opaque verbs with derivational prefix: *KRESLIT* (imp.) — *ZKRESLIT* (perf.) 'to draw' — 'to distort';
(d) non-prefixed verbs with the prefix-like onset (which is actually the initial part of the root): *ZLOBIT* (imp.) 'to misbehave'.

The prefixes (in (a–c)) and pseudo-prefixes (in (d)) were in all groups *z-* and *u-*, i.e. they were homonymous with respect to their functions. Each group included 15 perfective and imperfective forms.

Fillers were pairs of real perfective and imperfective verbs with different prefixes than the target words: *pod-*, *roz-*, *na-*, *vy-*. Their subgroup included semantically transparent prefixed verbs derived of foreign words with the same prefixes as targets e.g. *devastovat* (imp.) — *zdevastovat* (perf.) 'to devastate'.

Pseudo-words were generated by changing one or two letters (a vowel with another vowel and a consonant with another consonant) in other real words both with prefixes *z-*, *u-* and prefixes different to those used with fillers. Half of the pseudo-words had prefixes and the other half appeared in their basic form.

The items were divided into three blocks. Their order was randomized, so was the order of items in each block (for each participant).

PROCEDURE

Participants performed a lexical decision task with reaction time measurements.[2] The experiment was designed in E-Prime software (E-Prime, v. 1.2; Schneider — Eschman — Zuccolotto, 2002). First, the fixation sign * appeared on the screen for

2 In Experiment 1, participants made lexical decisions over the same targets in all three conditions, i.e. the frequency of the targets in all three conditions was the same and the differences in the RTs in the three conditions thus could be unambiguously attributed to the differences in prime — target relation. In Experiment 2, it was not possible to construct the experiment such that one target could be combined with both a derivational and an inflectional prefix while at the same time controlling the length of the primes in the critical conditions. Consequently, if participants performed repetition priming also in Experiment 2, several variables would be involved and confounded (prime — target relation, the length and frequency of the target, overlap between prime and target in letters etc.) and it would not be possible to unambiguously identify the origin of the differences in the RTs. Therefore we decided to simplify the procedure by employing a simple lexical decision task which made the interpretation of the data more straightforward.

500 ms, then the lexical stimulus presented and remained on the screen until the subject responded, but maximally for 1500 ms. A blank screen followed for the next 500 ms.

Stimuli appeared in the middle of the screen in small green letters printed in boldfaced Courier New script. Participants were supposed to classify the target as a word or non-word as rapidly and as accurately as possible by choosing the YES button for words and the NO button for non-words. Before the testing itself, there was a practice trial. Each block started with three filler items that were not included in the analysis. One session lasted approximately 25 minutes.

RESULTS AND DISCUSSION

The results of this experiment are depicted in Table 4 presenting RTs of inflectional, derivational and non-prefixed targets. As stated earlier, it was not possible to match the groups with respect to frequency which is a known factor affecting response times. The presented RTs thus must be interpreted relative to their frequency, with higher frequency items being expected faster and lower frequency items being expected slower, yet independently from their adherence to a particular category (inflected vs. derivational; opaque vs. transparent). Table 4 shows that the two groups with the highest frequency (base inflected and base opaque) also have the fastest RTs, confirming that frequency indeed affects the response times in the expected manner.

With respect to the research question concerning the morphological status of the prefixes and their transparency, it is especially the deviations from the RTs as expected due to frequency that are of special interest.[3]

	Targets (*z-*, *u-*)						
	Inflection		**Opaque derivation**		**Transparent derivation**		**Non-prefixed verbs**
Example	ZMIZÍ pref.	MIZÍ base	ZKRESLÍ pref.	KRESLÍ base	ZKRÁTÍ pref.	KRÁTÍ base	ZLOBÍ base
FRQ	28169	83953	76188	95676	15779	42577	20251
FRQ log	5.4498	5.924	5.8819	5.9808	5.1981	5.6292	5.3064
RTs (ms)	636.1	607.3	644.9	613.1	638.1	627.5	631.7

TABLE 4: Mean RTs and mean group frequencies of the inflectional, derivational and non-prefixed targets.

The comparison between the inflected and transparent derived forms reveals that both their frequencies and reaction times are comparable (and in fact do not differ statistically either).[4] If they were of a different nature as hypothesized by some

3 Because the frequency of the compared groups is not the same, the analysis of the data of this experiment is predominately descriptive, since using usual statistical tests would confound the factors frequency and morphological/semantic status.

4 Note that such direct comparison and conclusion would not be possible if the experiment was performed in the priming paradigm. In that case, only the responses to the targets (the

authors, they should be processed differently (with inflected forms undergoing complete decomposition) which should be reflected in their response latencies. Thus, we do not find any support for psycholinguistic reality of the assumed distinction. Caution is however necessary since this interpretation is based on zero difference which could be also caused by the lack of the sensitivity of the present method. The fact that the method was able to detect another addressed distinction (see below), however, speaks to the claim that the absence of the effect is caused by the absence of the distinction in the linguistic material.

The second research question addressed in this experiment concerned the processing of derived transparent and opaque forms. When we compare the frequencies and RTs of the higher frequent opaque bases (613.1 ms) than the lower frequent transparent bases (627.5 ms), we see that the RTs copy the frequencies with the more frequent group being faster. This difference was also confirmed statistically: ANOVAs with 2 × 2 design with factors base/perfective and opaque/transparent revealed an interaction between the two factors that was marginally significant in $F1(1,19) = 4.3$, $p = .062$ and significant in $F2(1,58) = 4.9$, $p < .0.05$. The subsequent t-tests revealed that the difference between the base forms was significant ($t(1,19) = 2.3$, $p < .05$). The same pattern should be observed also when comparing the higher frequent opaque (644.9 ms) and lower frequent transparent (638.1 ms) perfective forms. However, the RTs of the two groups are statistically the same ($p > .05$). Hence, when taking the frequency into account, the opaque perfective forms are processed slower than the transparent perfective forms. This result parallels the results of previous research exploring the processing semantically transparent and opaque complex forms. Slower RTs for opaque forms were observed e.g. in works of Nikolova and Jarema (2002), Marslen-Wilson et al. (1994), Slabakova (2001), Jarema et al. (1999) or Zwitserlood (1994). According to Schreuder and Baayen's (1995; 1997) morphological models, there are two parallel access routes interactively converging on the correct meaning representation, one based on the whole form information (whole word activation; a direct route) and the other on morphemic decomposition (morphemic activation; a decompositional route). The latter comprises three stages (segmentation, licensing and combination), during which complex words are segmented into affixes and stems, then the compatibility of subcategorical properties of these constituents is checked and the lexical representation is computed from the meanings of these constituents. Finally, the activation feedback takes place when the activated representations are mapped. In the case of opaque words, the right meaning cannot be obtained from its constituents unlike in case of transparent forms and therefore causes delay in processing for conflicting outcome of the direct route and the decompositional route.

Along the claims of the previous studies on the processing of transparent and opaque complex words we interpret the present results as indicating that while

bases) could be compared, which differ significantly (the bases of the inflected primes are double so frequent as the bases of the transparent derivational primes). Consequently, it would not be clear whether the expected faster RTs in the inflected condition would be due to the higher frequency of the targets or due to the morphological relationship between the target and the prime.

transparent forms are immediately decomposed into constituents and their meaning representation is accessed, opaque forms need to be reanalysed after decomposition since the meaning representation cannot be reached through the meaning of the constituents.

CONCLUSIONS

In the present study, we investigated the role of morphology and semantic transparency/opacity in the processing of morphologically complex (prefixed/suffixed) nouns and verbs. The main goal of Experiment 1 was to examine whether Czech derived and inflected word forms (nouns, verbs) are stored and processed in the same or different manner. Experiment 2 focused on the processing of prefixed verbs addressing (a) the distinction (albeit putative) between derived and inflected prefixed verbal forms and (b) the role of semantic transparency/opacity in their processing.

Experiment 1 showed faster processing of primed inflected forms compared to derived ones and no differences in the processing of primed identical and inflected forms. The results revealing different processing of derivation and inflection thus provide evidence in support of the Split Morphology Hypothesis also in the highly-inflective Czech language which, to the best of our knowledge, has not been yet the subject of similar experimental psycholinguistic research. The results further indicate that during the processing of inflectionally related forms, the same lexical entry is accessed. On the other hand, the processing of a base and a derived form either involves more complex processing (e.g. through activating more lexical nods) or two different lexical entries.

Experiment 2 did not bring evidence in support of the distinction between inflectionally and derivationally-formed prefixed verbs. Rather than seeing these results as counterevidence to the SMH, we interpret them as confirming the claims according to which "purely" aspectual verbal prefixes do not exist and thus all prefixed verbs fall into one category (Maslov, 1963; Komárek, 2006; Veselý, 2010). We assume that "purely" aspectual verbal prefixes are only a linguistic construct that does not correspond to the psycholinguistic reality. However, this interpretation must be taken with caution since it is based on zero differences between the processing of the two assumed types of prefixed verbs.

The second goal of Experiment 2 was to explore the processing of transparent vs. opaque prefixed verbs. The results revealed a slower processing of semantically opaque verbs (relative to their frequency) implying that semantic transparency affects lexical storage and access of morphologically complex words. They also indicate that semantically transparent derived forms are at least partly decomposed. Both these findings are consistent with the parallel dual-route activation model proposed by Schreuder and Baayen (1995) according to which two routes (direct and decompositional) are activated in parallel in the recognition of a complex word. The direct route activates a full-form representation, while the decompositional route proceeds via representations of individual morphemes. Transparent prefixed

verbs are processed faster because both the direct and the decomposition route contribute to the word recognition. The retrieval of opaque prefixed verbs is delayed due to the conflicting outcome of the direct route and the decomposition route, which misleadingly attempts to construct the meaning of the complex word from the meanings of its individual constituents. Schreuder and Baayen's model also includes a mechanism of activation feedback between the lemma nodes (linked with a syntactic and semantic layer) and the representations of constituents that are fully present in the complex words. The mechanism allows cumulative frequency effects for transparent complex words, but not for opaque ones. Gradually, the activation feedback tunes the system towards an advantage for the decomposition route which also results in a processing benefit for the transparent, but not the opaque words.

Our study represents the first attempt to address the differences in processing of derivational and inflectional suffixes and prefixes in Czech, as well as the role of transparency/opacity in the processing of complex words. Further research is necessary to extend our knowledge about the processing of complex language forms, both in Czech and in other (often rarely explored) languages.

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APPENDIX

Target		**Prime**	
dřu	dřu	dřeš	dříč
kopu	kopu	kopeš	kopáč
kreslím	kreslím	kreslíš	kreslíř
lezu	lezu	lezeš	lezec
piju	piju	piješ	pijan
plavu	plavu	plaveš	plavec
rvu	rvu	rveš	rváč
řečním	řečním	řečníš	řečník
štvu	štvu	štveš	štváč
zabiju	zabiju	zabiješ	zabiják
zvoním	zvoním	zvoníš	zvoník
žebrám	žebrám	žebráš	žebrák
cíl	cíl	cílem	cílíš
čich	čich	čichem	čicháš
dřep	dřep	dřepem	dřepíš
hlt	hlt	hltem	hltáš
hmat	hmat	hmatem	hmatáš
klam	klam	klamem	klameš
kmit	kmit	kmitem	kmitáš
kouř	kouř	kouřem	kouříš
kov	kov	kovem	kováš
lov	lov	lovem	lovíš
obal	obal	obalem	obalíš
pláč	pláč	pláčem	pláčeš
vrt	vrt	vrtem	vrtáš
zápas	zápas	zápasem	zápasíš
zob	zob	zobem	zobeš

EXPERIMENT 1: Materials.

Inflection

Target *u-*	
ucítí	cítí
udělá	dělá
uhlídá	hlídá
uloví	loví
umlátí	mlátí
upeče	peče
uslyší	slyší
usmaží	smaží
uspoří	spoří
uškodí	škodí
ušpiní	špiní
utrápí	trápí
uvaří	vaří
uvěří	věří
uvidí	vidí

Target *z-*	
zbledne	bledne
zbohatne	bohatne
zboří	boří
zdědí	dědí
zhatí	hatí
zhřeší	hřeší
zhubne	hubne
zkazí	kazí
zkropí	kropí
zkrotí	krotí
zláká	láká
zmaří	maří
zmate	mate
změří	měří
zmrzne	mrzne

Transparent derivation

Target *u-*	
ubrousí	brousí
udrží	drží
udupe	dupe
ukolébá	kolébá
ukončí	končí
ukotví	kotví
umaže	maže
umyje	myje
upálí	pálí
uřeže	řeže
ušlape	šlape
utají	tají
utlačí	tlačí
utlumí	tlumí
utvoří	tvoří

Target *z-*	
zbourá	bourá
zbrousí	brousí
zbrzdí	brzdí
zdeptá	deptá
zhasne	hasne
zhodnotí	hodnotí
zchátrá	chátrá
zchladí	chladí
zkrátí	krátí
zmešká	mešká
zmírní	mírní
zmrazí	mrazí
znásobí	násobí
zpracuje	pracuje
ztlumí	tlumí

Opaque derivation

Target *u-*	
udělí	dělí
uchová	chová
ukáže	káže
ukryje	kryje
uplatí	platí
upraví	praví
usoudí	soudí
uspěje	spěje
uteče	teče
uvalí	valí
uváží	váží
uvede	vede
uvrhne	vrhne
uzdraví	zdraví
uzná	zná

Target *z-*	
zdraží	draží
zdrhne	drhne
zdrží	drží
zchytá	chytá
zjedná	jedná
zjistí	jistí
zklame	klame
zkreslí	kreslí
zmíní	míní
zmydlí	mydlí
zradí	radí
zřídí	řídí
ztrhá	trhá
zvětrá	větrá
zvládne	vládne

Non-prefixed verbs

Target *u-*	
ubytuje	
udeří	
udolá	
uhodne	
uhrane	
umístí	
unaví	
uniká	
určí	
urguje	
usiluje	
uskupí	
uspíší	
uštkne	
utuží	

Target *z-*	
zdobí	
zdolá	
zdvihá	
zkouší	
zlatí	
zlobí	
zmatkuje	
zmítá	
zmlkne	
značí	
zpívá	
zrcadlí	
zvedá	
zvoní	
zvučí	

EXPERIMENT 2: Materials.

ABSTRAKT:
Zpracování a reprezentace různých typů českých afixů. Studie se zabývá zpracováním morfologicky komplexních slov v češtině. V experimentu 1 využíváme morfologický *repetition priming* k ověření tzv. Split Morphology Hypothesis, tj. zjišťujeme, zda jsou slovní formy vzniklé derivací vs. flektivně v českém mentálním lexikonu uloženy stejným, či odlišným způsobem. Výsledky ukazují, že primingové efekty jsou podstatně silnější v případě flektivně vzniklých forem než v případě forem derivovaných, což svědčí o odlišném zpracování flexe a derivace v češtině; zatímco flektivně vzniklé formy jsou během zpracování rozloženy úplně, derivované formy nejsou rozloženy buď vůbec, nebo jen částečně. V experimentu 2 se zabýváme dvěma výzkumnými otázkami. Zaprvé testujeme psycholingvistickou realitu lingvistické distinkce mezi dvěma typy slovesných prefixů: (a) prefixy „čistě" vidovými (které z nedokonavého slovesa činí sloveso dokonavé, srov. např. *hřešit — zhřešit*) a (b) prefixy derivačními (např. *krátit — zkrátit*). Výsledky neposkytují pro tuto distinkci žádné psycholingvistické důkazy. Zadruhé zkoumáme, jakou roli má při zpracování jazyka sémantická transparentnost. Experiment přináší důkazy o tom, že netransparentní derivovaná slovesa jsou zpracovávána pomaleji, což je s největší pravděpodobností způsobeno jejich dvojím vyhledáváním / dvojí reanalýzou.

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